

Analysis of Accessibility of the e-Learning Platforms According to the WCAG 2.0 Standard Compliance

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Abstract - Access to information and communication for people with disabilities through modern technology is an important requirement for their social inclusion in the institutions of every country, European Union and other international organizations. Learning management systems (LMSs) have to be accessible in order to enable people with disabilities to take part in the educational and learning processes. Although the accessibility of the learning management systems is improving, they still possess significant challenges for users with disabilities. This paper analyzes the accessibility of the latest public version of the respective LMSs such as Moodle, Eliademy, Docebo, Sakai and ATutor for people with disabilities. The considered criteria are with different levels of compliance in accordance with the Web Content Accessibility Guidelines (WCAG) 2.0. The goal of this analysis is not to rate or rank these LMSs for accessibility, but to highlight some points about how the presence or absence of certain key usability/accessibility features can significantly impact users' experience. The analysis covered the following types of impairments: visual, hearing and motor impairments. Recommendations derived from the practical use of these systems will be used to support decision-making in the project activities of CROSS4ALL IPA2 for selecting a suitable e-learning platform to increase the digital literacy for e-health of the population of the border area for whom this project is intended.

I. INTRODUCTION

Many EU activities in the last decade have been associated to improve the living conditions of the EU population in general, with an emphasis on the older population, young children and people with disabilities. The trend of aging of the population in Europe and the application of the principles of "equal treatment for all people" regardless of the problems they live in, on which location and in which country, showed that not everywhere the living conditions of the entire population, and especially the vulnerable categories as older people, children and people with disabilities are equal. When it comes to these vulnerable groups, in some countries the standards set are satisfied, while in others are still not. In order to improve the living conditions of these vulnerable categories of citizens, the EU, in large percentage, directs its project activities towards these vulnerable groups, i.e. funds projects aimed at raising people's knowledge about the needs and opportunities of vulnerable categories of people, improving health and social services, and applying IT

technologies to lighten the lives of older people, children and the disadvantaged population. In this context, one of the conditions to take advantage of the opportunities offered by IT is remote (distance) learning, which has long been a world trend, but now, by applying standards for learning systems that provide accessibility for all citizens, regardless of whether they are older people, children or citizens with a disability. The requirements of the project activities of EU projects are focused towards creation of affordable e-learning systems that are made according to the WCAG 2.0 and W3C standards which provide "accessibility of the website or the system for all". Particularly important is their application in the improvement of health and social services to a broad population that can significantly contribute to raise digital e-health literacy.

Due to the importance of the concept, this article is devoted to the analysis of several reputable e-learning systems in terms of their accessibility and convenience for use by vulnerable groups. Because typically e-learning systems are put on the web, the W3C's Web Accessibility principles are applied. Accessibility is defined by the ISO 9241-171:2008 standard and according this standard it can be said that an online educational environment is accessible, when everyone, despite its personal characteristics and environment type is capable to access the information provided via the learning objects [1]. Consideration has been given to the four principles i.e. Perceivable, Operable, Understandable and Robust that should provide the basics of web accessibility with 12 guidelines for the authors [1]. For each guideline, criteria for success for testing according to WCAG 2.0 are defined. In order to meet the needs of different groups and different situations, three levels of compliance are defined: A (lowest), AA and AAA (highest) [2]. Successful and advisory techniques that create the level of accessibility are given. According to the mentioned principles, the special guidelines have been developed by the W3C community to help developers and web content creators to create content on the web that will comply with the WCAG 2.0 standards.

European Unified Approach for Accessible Lifelong Learning (EU4ALL) by proposing the concept of accessible lifelong learning, endeavors the elimination of obstacles to the interlinked worlds of education by using suitable technologies [3].

This paper takes into consideration the five e-learning platforms that are most used by the community according to Gartner, which does not mean that they are the best for all e-learning areas. The aim is to analyze the accessibility of LMSs for people with disabilities considering the criteria with different levels of compliance in accordance with the Web Content Accessibility Guidelines (WCAG) 2.0. Given the limited space that we have and the extensive material intended for this research, only the final results of the research are given, without detailing the synthesized data. The explanations for each data in the table are not included in the paper and it is planned to be published later.

The paper is structured as follows. After the introduction, considerations related to the topic, the opinions of other authors and their experiences so far have been taken into consideration. The focus is also on exploring e-learning platforms intended for e-health considering our project focus. The next section is devoted to explaining the applied methodology and the principles underlying the analysis. The analysis of the platforms according to WCAG 2.0 principles and access levels follows. It is planned that the recommendations given in this paper will be used to support decision-making in the project activities of CROSS4ALL IPA2 for selecting an e-learning platform to increase the digital literacy for e-health of the population of the cross border area for which the project is intended. Last section provides concluding remarks and directions for further work.

II. RELATED WORKS

Many authors consider LMSs and their accessibility from different points of view. When the accessibility in context of e-learning is considered, many authors highlighted that there is a need to define criteria for instructors, authors of the contents and e-learning specialist that create and run activities on the web. When somebody talks for inclusion and accessibility, it is necessary to have some generally accepted definition that will be uniquely defined and will clarify which are those common visual, verbal and kinetic dysfunctions that affect the style of learning and according to which it is necessary to design content accessible to everyone [4]. According to Oxford dictionary, accessibility and inclusion are defined as "typical physical and mental conditions that limit the movement, sensitivity or personality activities". In this context, the authors argue that for blind people or people with visual impairments [5], a text or audio alternative for graphics can be provided by text-to-speech technology or Screen reader technologies that are achieved by applying software like JAWS [6], Windows Eyes [7], NDVA [8], and Voice over Mac [9], ORCA (Linux) [10] and Android Trackback [11]. Certainly, keyboard accessibility should be considered instead of using the mouse and multimedia contents. Audio description is of significant importance in multimedia content. For people with reduced visual capability, this means an opportunity to increase the screen or to use a Browser with Zoom features. For individuals with hearing disabilities, titles,

transcripts, graphics matching, and visual presentations should be defined.

People with significant motor impairment generally face barriers related to the using of a mouse or aspects of a keyboard to access web content. This group will often rely on various keyboard technologies to access web content, including a "large key" keyboard, an onscreen keyboard, or a scanning keyboard that is operated with a single switch or head mouse [4].

Other aspects of disability consider some cognitive impairments and learning disabilities [12]. There is a reference to material consistency, predictability, complexity, and memory, that the ability to understand and match the materials is of particular importance [4].

It is also important that the material itself has to be adapted to the personality and provide a framework for problem solving. The users have to have the ability to remember and recognize, but also dedicate the task that has to be solved. They conclude that in order to achieve all this, it is necessary the material to be written in a simple language, without sarcasm, idioms, metaphors, and other risky forms that lead to ambiguity. Therefore, all these learning systems should follow the standards and specifications of WCAG 2.0 [12], [4], ATAG 2.0 [13], ARIA 1.0 [14] and be accessible to all (APIP) [15]. The AChecker Web Accessibility Checker [16] evaluates the accessibility of e-learning and other web content. It provides a list of known, likely and potential accessibility issues, as well as detailed description of potential strategies to improve issues.

In [12] authors take into consideration holistic model of e-learning accessibility which considers learners' needs. There are also efforts to specify some e-learning critical success factors (CSFs) as perceived by university students [17]. CSFs were grouped into 4 categories including several measures.

Acosta and Lujan-Mora in [18] had made a comparative study of three Learning Management Systems (LMSs), Moodle, Sakai and system named ABC, developed in Ecuador in order to evaluate the levels of accessibility according to the needs of users. They analyzed and compared the selected LMSs according to accessibility criteria, considering functional tasks in scale with 6 levels of accessibilities which can be used for decision making and selection of LMS from the teachers' and students' aspects.

Aldheleai et al. considered the concept of cloud computing as a new inspiration for creative learning environment which provides a high level of accessibility, solving the problems with hardware and software [19]. They reviewed the usability of cloud technology for third world countries like Yemen, trying to give brief introduction to cloud computing and cloud-based LMSs and summarize the main advantages and drawbacks of using them for online learning. They compare services offered in each layer and concept of the cloud computing with traditional IT, taking into consideration some well-known cloud e-learning platforms, regarding the benefits of using cloud based LMSs, risks and disadvantages. They conclude that

these platforms save a lot of efforts of organizations as well as learners and enable people living in underdeveloped countries to come over all LMS obstacles as soon as they get internet connections [19]. According to [20] the cloud concept implies opportunities for the inclusion of new technologies as Internet of Things (IoT) and Ambient Assisted Living and increasingly changes the manner of living today, especially when some vulnerable groups are taken into consideration. This is especially important when some e-learning systems for these vulnerable groups (as elderly people, children, and people with disabilities) have to be created [20].

Póljanowicz et al. in [21] had made analysis of e-learning platform at the Faculty of Health Sciences, Medical University of Białystok on 90 students and they found that some students who have achieved a poor result due to blindness or inability to attend to the classes, have achieved significant success with this platform because they have freedom for the timing of learning, learning time, increased opportunities for improvement and enrichment of syllabuses and additional materials for learning with which students show an enviable result in e-exams. The effects of applying this system are highly appreciated by students and professors [21].

Komenda et al. described OPTIMED Platform suitable for e-learning systems for effective harmonization of medical and healthcare curriculum [22], allowing access to necessary meta information for the courses as well as all learning courses for the students. In this case, extreme programming for creating OPTIMED Platform is used for conceptual data model and the fundamental attribute in all phases. The platform is suitable for higher education institutions and aims to improve the medical and healthcare courses and remove duplicate contents. They state that the accessibility is in very high level regarding the students' ability and accessibility [22].

However, in order to detect the crucial accessibility problems in the current LMSs, a combination of accessibility expert and end-user evaluation is exceptionally beneficent [23].

III. METHODOLOGY USED FOR ANALYSIS OF E-LEARNING PLATFORMS THROUGH WCAG 2.0

The accessibility testing and evaluation using an analytical method was performed on the latest public version of the respective Learning management systems (LMSs) such as Moodle [24], Eliademy [25], Docebo [26], Sakai [27] and ATutor [28]. Accessibility testing was performed using same criteria for the mentioned LMSs. The goal of this evaluation is not to rate or rank these LMSs for accessibility but to educate the public about how the presence or absence of certain key usability/accessibility features can significantly impact users' experience. The analysis covered the following types of impairments: visual, hearing and motor impairments.

Table I shows the features and tests relating to some of the common assistive technologies (ATs). For the

purpose of Screen reader criterion, the software Thunder [29] is installed and features like Screen Reader accessible player, Listing headings of a page, Accessing bypass links which people with visual disabilities can use are tested for the given platforms. With the second feature Keyboard accessibility it was examined whether the user can navigate only by using the keyboard, for example, via shortcuts or pressing tab button. The third feature Audio description examines whether the user can add an audio file as an alternative to the video. Using the browser's zoom feature it is verified that all content and not only parts of it can be resized and the feature Screen magnification is established.

People with hearing impairments experience fewer barriers in accessing web content than people with vision impairments. Using feature Captions (transcript) it is examined whether the platform offers a way to add captions/transcript (either to upload file with captions or to enter captions manually).

People with significant motor impairment generally face barriers associated with using a mouse or aspects of a keyboard to access web content. Windows Speech Recognition is used to navigate and use the platform (access various menus, links, scroll down/up, add assignments, access calendar and edit events etc.).

The established criteria from Level A (must have) and Level AA (should have) that affect the functional availability of the five learning management systems are in accordance with Web Content Accessibility Guidelines (WCAG) 2.0 through the World Wide Web Consortium (W3C) and they are shown in Table II and Table III, respectively.

Table IV provides an analysis of criteria with varying degrees of compliance in order to gain a better understanding of the accessibility of each listed platform.

IV. ANALYSIS OF SELECTED E-LEARNING PLATFORMS ACCORDING TO WCAG 2.0 COMPLIANCE

The analysis was performed on the latest public version of the respective Learning management systems (LMSs) such as Moodle, Eliademy, Docebo, Sakai and ATutor, considering the WCAG 2.0 standards and criteria.

Moodle is one of the most popular open source LMS options available today. It features dashboards, learner tracking, and multimedia support. This open source Learning Management System also gives the ability to create mobile-friendly online courses integrating third-party add-ons. One of the standouts of this tool is the user community.

Eliademy is completely free for educators and eLearning facilitators. It features eLearning course catalogs, eLearning assessment tools, and even a mobile Android application for educators who wish to develop mobile learning modules for their on-the-go audiences.

Docebo is a cloud-based LMS solution to provide training programs for employees, partners and customers. Docebo's various features and applications can be enabled or disabled based on the company's

needs. Users can deliver content, manage training, track certifications and reward learners through the platform. It provides unlimited storage, courses, bandwidth and admins. The system can be integrated with third-party applications as well.

Sakai is a free open source LMS that gives community members it serves the license to change and tweak its structure to better suit their needs. The program boasts of extreme flexibility and wide variety of features, making it the top LMSs of choice by a number of the world's leading colleges and universities as well as nonprofit organizations that promote education. Sakai continues to improve as members of its community strive to create the perfect learning experience for anyone and make Sakai the ultimate learning management system capable of supporting various teaching methodologies.

ATutor as an open source LMS boasts a variety of useful features, ranging from e-mail notifications to file storage. One of the most notable highlights of ATutor is that it is user-friendly and easily accessible, which makes it an ideal match for those who may be new to the world of e-learning design and development. It also offers a wide variety of themes to speed up the e-learning course development process, as well as e-learning assessment tools, file backups, analytics and poll integration.

The analysed features related to assistive technologies are given in Table I, while Table II, III and IV show the criteria according to the WCAG 2.0 standard.

TABLE I. ANALYZED FEATURES RELATED TO ASSISTIVE TECHNOLOGIES

	Moodle	Eliademy	Docebo	Sakai	ATutor
Visual Impairment					
Screen reader	Yes ⁱ	Yes	Yes	Yes	Yes
Keyboard accessibility	Yes	Yes	Yes	Yes	Yes
Audio description	Yes	Yes	No	Yes	Yes
Screen magnification	Yes	Yes	Yes	Yes	Yes
Hearing Impairment					
Captions (transcript)	Yes	No	Yes	No	Yes
Motor Impairments					
Speech recognition	Yes	Yes	Yes	Yes	Yes

TABLE II. CRITERIA FOR LEVEL A OF COMPLIANCE (MUST HAVES)

	Moodle	Eliademy	Docebo	Sakai	ATutor
Add text alternatives for images, video, audio	Yes	Yes	Yes	Yes	Yes
Create document structure through headings, lists, and table headers.	Yes	Yes	Yes	Yes	Yes
Generate valid HTML markup	Yes	Yes	Yes	Yes	Yes
Help authors avoid and correct mistakes and Document the user interface, including all accessibility features (Undo/Redo, Save/Cancel, Restore default, Leave Page/Stay on Page, Auto-Save Option)	Yes	Yes	Partial ⁱⁱ	Yes	Yes

TABLE III. CRITERIA FOR LEVEL AA OF COMPLIANCE (SHOULD HAVES)

	Moodle	Eliademy	Docebo	Sakai	ATutor
Provides adequate documentation on accessibility features	Yes	No	No	Yes	Yes
Makes the most accessible authoring options the default	Yes	No	No	Partial	Yes
Prompts content authors for accessibility information when it has not been provided	Yes	No	No	No	Yes
Offers accessibility checking and repair functions	Yes	No	No	Yes	Yes

ⁱ also provides Screen reader helper

ⁱⁱ does not preserve the existing content that has been edited and does not provide Auto-Save Option if the user made mistake and left the page

TABLE IV. ADDITIONAL CRITERIA FOR ACCESSIBILITY

	Moodle	Eliademy	Docebo	Sakai	ATutor
Keyboard Access	Yes	Yes	Yes	Yes	Yes
Skip to main content link	Yes	No	No	Yes	Yes
Within-Page Navigation					
HTML Heading Markup	Yes	Yes	Yes	Yes	Yes
ARIA landmarks	Yes	No	No	Yes	Yes
Logical Tab Order	Yes	Yes	Partial	Yes	Yes
Visible Focus	Partial	Partial	Partial	Yes	Yes
Labelled Forms with Instructions					
Use of HTML Label element	Yes	No	Yes	Yes	Yes
Use of title attribute	No	No	No	No	Yes
Accessible (ARIA-enabled) feedback	Yes	Yes	No	No	No
Personal Preferences					
Font types and sizes	No	No	No	No	Yes
Font color and background color	No	No	Yes	No	Yes
Navigation elements (breadcrumbs, links, table of content)	No	No	Yes	No	Yes
Topic numbering to organize content numerically	No	No	No	No	No
Choice of themes	Yes	No	Yes	No	Yes ⁱⁱⁱ
Preferred content Type	No	No	No	No	Yes
Accessible Authoring					
Visual editor is keyboard accessible ^{iv}	Partial	Partial	Partial	Partial	Partial
Alert for no text alternative for an image	Yes	No	No	No	Yes
Math equations	TeX	TeX	No	No	LaTeX
The cursor get trapped inside the editor	No	Yes	No	No	No
Accessibility check is provided by editor tool	Yes	No	No	Yes	Yes
Timing					
Session timeout alert and extension option	No	No	No	Yes	Yes

Table I shows that Moodle and ATutor support all analyzed features related to assistive technologies (ATs). The other LMSs lack support for only one feature i.e Eliademy and Sakai Captions (transcript), while Docebo - audio description. The advantage of Moodle in terms of ATs is that it supports Screen reader helper, found in the visual editor.

To evaluate LMSs' ability to create accessible e-learning content it is necessary for the system to satisfy the criteria according to WCAG 2.0 standards. Some criteria required for Level A are given in Table II. In this context all LMSs except Docebo meet the analyzed criteria. The only criterion which it does not fully satisfy is Help authors avoid and correct mistakes and Document the user interface. We evaluated this criterion as Partial because Docebo does not preserve the existing content that has been edited and does not provide Auto-Save Option if the user made mistake and left the page.

Table III gives an overview of some criteria recommended to meet Level AA of compliance. In terms of these criteria, there are significant differences. Moodle and ATutor fulfill the established criteria, while Eliademy and Docebo do not. For Sakai the criteria Makes the most accessible authoring option the default and Prompts content authors for accessibility information when it has not been provided are evaluated as Partial and No respectively because no math

equations and no alert for lack of alternative for an image are provided.

We want to emphasize some criteria that have a significant impact on e-learning for people with disabilities as shown in Table IV. Criteria Skip to main content link (which becomes visible after pressing tab button), ARIA landmarks and Accessibility check is provided by editor tool are fulfilled by three of the analyzed systems i.e. Moodle, Sakai and ATutor. The only criteria that are satisfied by all systems are Keyboard Access and HTML Heading Markup. In terms of LMS Accessibility, ATutor has vital advantages, as it is the only analyzed system that satisfies the criteria Use of title attribute and Preferred content type. The last mentioned criterion is crucial because it enables people with different disabilities to choose alternative for textual, visual and audio content, suitable to users' needs. The criterion Visible Focus is fully satisfied only by Sakai and ATutor, while in the other three systems it is evaluated as Partial. It needs some improvement in order to make it easily visible for people with low vision. Only two of the analyzed systems (Docebo and ATutor) provide users with the option to choose desired colors and satisfy the criterion Font color and background color.

V. CONCLUDING REMARKS

Each of analyzed LMSs presents a different learning platform with unique features. Although the

ⁱⁱⁱ themes need to be downloaded

^{iv} partial means that the visual editor supports shortcuts, but not tab navigation

accessibility of learning management systems is improving there are still significant challenges for people with disabilities. For people experiencing disability, some aspects of the LMS may present difficulties. Each LMS has core features that cannot be modified and variable features which can be adapted for the specific accessibility requirements of people with disabilities. According to the CROSS4ALL requirements, the criteria from WCAG 2.0 Level AA compliance need to be satisfied.

These analyses are made in real environment, on public accessible e-learning systems, evaluating the criteria needed for the standard as well as necessary features. Perceptions from the practical use of the LMSs given in this paper will be used to support decision-making in the project activities of CROSS4ALL IPA2 for choosing an appropriate e-learning system to increase the digital literacy for e-health of the population of the cross border area for which the project is intended.

The final purpose is to provide website with e-learning system that will increase e-health and medical digital literacy for the cross border region, including all partners' contribution for cross border population with special focus on the elderly people, people with disabilities and children.

Our further testing will continue with evaluation of the criteria of Level AAA for Moodle and ATutor, as these two systems are particularly prominent in terms of availability for people with disabilities.

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